CLINOVATE
Advances in Medicine and Healthcare
eISSN: 3107-4421

Volume 1, Issue 3, Sept-Dec 2025
DOI: 10.5281/zenodo.17976252

Perspective

Surgical Training in the Era of Robotics: Who Bears the Actual Cost of this Learning Curve?

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Abstract

The rapid expansion of robotic surgery across surgical subspecialties has transformed operative practice in India, yet its integration into formal surgical training remains uneven. While robotic platforms offer advantages in visualization, ergonomics, and precision, they introduce a distinct learning curve that carries implications for patient safety, trainee competence, and ethical responsibility. Current training pathways are highly variable, often relying on limited institutional exposure, short-term fellowships, or industry-led courses, resulting in inconsistent skill acquisition. Evidence suggests that early phases of robotic adoption are associated with prolonged operative times and variable outcomes, underscoring the need for structured safeguards. Simulation-based training has emerged as a critical component in mitigating these risks, though access remains limited. This perspective examines the educational, ethical, and institutional challenges of robotic surgery training in India and emphasizes the need for standardized credentialing, simulation integration, and nationally applicable training frameworks to ensure equitable and patient-centred surgical care.

Keywords: *Robotic surgery, Surgical education, Simulation-based training, Learning curve, Patient safety*

Robotic surgery has long progressed from yet another technological innovation to an increasingly integral component of modern surgical practice. In India, robotic platforms are rapidly expanding across multiple surgical subspecialties and are often perceived as markers of precision, progress and superior patient care. For surgeons, robotic systems offer advantages of enhanced visualisation, improved ergonomics and refined instrument control. However, alongside this growth arises a critical question that warrants academic scrutiny: How are surgeons being trained in robotic surgery, and who bears the responsibility as well as the consequences of its learning curve?

Surgical training has historically been an apprenticeship-based model wherein competence is achieved only under expert supervision. The introduction of laparoscopy represented a paradigm shift where the acquisition of new psychomotor skills and their incorporation through simulation-based training became the norm. Now robotic surgery only further extends this evolution. Console-based operating requires mastery of the hand-eye dissociation, depth perception through three-dimensional imaging, precise clutching movements and a dedicated robotic team. These competencies differ substantially from those required in open or conventional laparoscopic surgery. And while these advances are rapid, formal exposure to them during postgraduate surgical training remains inconsistent. Access is often limited to select institutions, predominantly in the private sector. As a result, many trainee surgeons often complete residency with minimal experience in robotic surgery. And then pursue post-training exposure through fellowships or short courses which vary widely in structure, duration and educational depth.

The adoption of any new surgical technology is accompanied by a learning curve and robotic surgery is no exception. Several studies have demonstrated that early phases of robotic adoption are associated with prolonged operative times and variable outcomes as surgeons acquire familiarity with the platform and the workflow.[1] Although robotic systems enhance precision and ergonomics, they do not mitigate the risks associated with limited operator experience. Patients simply equate robotic surgery with superior outcomes without the consideration of these nuances. This underscores the importance of transparency and structured safeguards during the early adoption phases.

Ethical frameworks addressing surgical innovation emphasise the principles of patient safety, informed consent and outcome monitoring.[2] In robotic surgery, these responsibilities extend beyond an individual surgeon and over to training institutions and professional organisations. And the absence of nationally accepted, uniform credentialing standards risks inconsistent skill acquisition. This inadvertently place patients at the centre of the risks.

Here comes handy simulation-based training. It is truly a cornerstone of robotic surgical education. Virtual reality simulators and dry laboratory platforms allow surgeons to develop console-specific skills in a controlled environment. This helps in shortening the learning curve before performing live surgery.[3] Simulation has been shown to improve technical performance, enhance procedural efficiency and reduce error rates during early training phases. But access to these facilities remains limited in India. Be it due to financial constraints or infrastructural challenges or competing institutional priorities. Many surgeons continue to predominantly rely on live operative exposure for skill acquisition which raises concerns regarding patient safety.

Received: 16/10/2025, Accepted: 14/12/2025
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Thus, institutions that invest in robotic platforms bear a responsibility that extends beyond mere procurement and utilisation. Comprehensive training including protected learning time, adequate access to simulations, expert mentorship and timely outcome audits are the essential components of their safe implementation. Industry partnerships providing initial training and technical support are necessary and must be carefully regulated to uniformly match international standards. Training programs that focus solely on system operation may inadequately address critical aspects of surgical judgment, patient selection and complication management. Academic institutions and professional bodies should ensure that training remains structured and patient-centred. Exclusive reliance on individual initiatives for acquiring these necessary skills independently, perpetuates inequities in practice. Moreover, disparities in access to robotic training reinforces an existing divide between resource-rich and resource-limited centres causing profound implications in both surgical education as well as patient care.

The implications this has for surgical education in India is massive as India's healthcare system is characterised by considerable heterogeneity ranging from advanced tertiary centres to resource-constrained hospitals. In this context, indiscriminate adoption of robotic surgery causes more loss than benefit, as not all procedures or patients may be appropriate to be treated using robotic technology. From an educational perspective, robotic surgery should be integrated as an adjunct to foundational surgical training rather than trying to replace it. In any case, proficiency in anatomy, tissue handling, clinical decision-making and complication management remains indispensable. Technological proficiency without sound surgical judgment is just technical sophistication without any meaningful clinical benefit.

As the modality of robotic surgery continues to expand, the development of nationally applicable training and credentialing framework is imperative. Professional surgical bodies in India should establish consensus guidelines defining minimum training requirements, simulation mandates and ethical strategies. Accreditation of training centres to a set standard and integration of simulation into existing formal curricula could promote uniform competence while safeguarding patient safety.[4] Ultimately, the cost of the robotic learning curve should neither be borne by patients through avoidable risks nor by young surgeons through haphazard and financially burdensome training pathways. A collaborative approach involving institutions, professional bodies, the industry, educators and trainee surgeons is needed to warrant that technological advancement translates into equitable, ethical and meaningful improvements in overall surgical care.

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